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Consumers' practices and safety perceptions regarding the use of materials for food preparation and storage: Analyses by age group

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ABSTRACT

Food Contact Materials (FCM) are those intended to be in contact with food, during its production, handling, and storage. FCM contain chemicals that could migrate to the foodstuff, posing potential health concerns, and usage practices influence the level of migration. This study assesses the preferences, safety perceptions, and usage practices of Portuguese consumers regarding FCM used for cooking and food storage (cookware). An observational, quantitative, and transversal study was performed through an online survey created for this purpose, which involved 1179 Portuguese adults. Results were analyzed according to age. Safety was the factor considered most important when choosing cookware materials, although the choice criteria varied with age. The majority of respondents recognize the risk of food contamination through cookware. Stainless steel and glass were considered the safest materials for cooking. The materials most used to reserve food are glass and plastic. Older individuals carry out more maintenance of cookware and have greater knowledge about how to wash and store it. Regarding the FCM symbology, there is a general lack of knowledge. Our study demonstrates the need to disseminate reliable information to the general public about cookware, contributing to greater literacy in health and to less exposure to food contact chemicals.

1. Introduction

Since ancient times, Man has been looking for appropriate materials to prepare food. Cooking food may be regarded as a technological way of externalizing part of the digestive process, increasing food digestibility, reducing energetic costs, and contributing to the detoxification and defense against pathogens and toxins (Carmody and Wrangham, 2009). Preserving and preparing food are activities that require knowledge built empirically over many centuries and that today involve research and state-of-the-art technology. Food contact materials (FCM) are all those materials and articles intended to be put in contact with the food ingredients, from the production, storage, and handling process (Geueke et al., 2014). Different materials can be used in cookware, including copper, aluminum, non-stick coatings on aluminum or iron (including perfluorinated compounds, ceramic, and stone coatings), enamel, iron, black carbon steel, stainless steel, soapstone (steatite), ceramics (including clay), glass, plastics, and silicone.

FCM can contain food contact chemicals (FCC) that could migrate from the material itself to the foodstuff, posing potential health concerns if ingested in non-safe quantities by the consumer. Some examples are toxic metals (Dong et al., 2015), per- and polyfluoroalkyl substances (PFAS) (Carnero et al., 2021), aldehydes, ketones, phthalates and other plasticizers, phenol derivatives, acrylates and methacrylates (Miralles et al., 2021). The level of migration depends on several aspects such as temperature, contact time, food pH, or material integrity (Carvalho et al., 2022). Cookware usage practices may therefore influence the safety of FCM. For these reasons, the present study aims to assess the materials preferences, the factors that influence the selection of cookware, the safety perception, and the usage practices of a sample of Portuguese consumers regarding FCM used in food cooking and storage.

Sociodemographic factors, and particularly age, may influence consumers' behavior towards food and cookware. For example, a study on food purchase decisions demonstrated that compared with older generations, millennials (born 1981–1996), place more importance on convenience, and demand healthier and fresher food, but spend less time preparing food and spend less money on their expenditures on food at home (Kuhns and Saksena, 2017). As millennials are now the largest living generation, these features are likely to heavily influence the food and cookware retail market for years to come. Therefore, to explore the impact of age on cookware choices, safety perception, and usage

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practices, the data obtained in this study was analyzed by age group.

2. Methodology

2.1. Study sample

An observational, quantitative, and transversal study was carried out through an online questionnaire (Google forms®) specifically created for this study, in the Portuguese language. A pilot study of 12 participants was carried out to ensure the feasibility and fine-tune the questionnaire. The final questionnaire was disseminated through institutional social networks, and the recruitment period took place between November 15th of 2020, and January 30th, 2021. The study's total sample was composed of 1179 individuals aged between 18 and 101 years, residing in Portugal. No other non-inclusion criteria were defined. The project was submitted to The Ethics Committee of the School of Health Sciences and Technologies of Universidade Lusófona (EC.ECTS/P07.21). An in-depth ethical ethics analysis was waived since the project complied with data protection legislation and due to the non-interventional and non-clinical nature of the study. All the participants gave their prior informed consent before filling out the questionnaire, and the confidentially of the data was guaranteed at any moment.

2.2. Evaluated variables

The questionnaire was divided into three sections with a total of 34 questions. In the first section with 13 questions, sociodemographic data, general characteristics, and characteristics related to lifestyle and health were evaluated. Parameters such as age, gender, number of people in the household, level of education, average net monthly household income, and geographical area of residence were evaluated according to the division of the Nomenclature of Territorial Units for Statistical Purposes II (NUT II). In this group of questions, it was also evaluated whether the participant was involved in the choice of materials for cooking food for the family, whether they consider that they eat healthily, their dietary habits, smoking habits, and whether they work in the food/nutrition/health area. A second section with 9 questions, aimed at evaluating the choices and use of materials for cooking and storing food, some using images for easier identification and figures with the symbols described. People were asked if when purchasing pots/pans and food storage containers, how important was for them the following aspects: durability, price, design/aesthetics, convenience/advantages of the material, material safety, and sustainability and environmental issues (recycled/recyclable material). They were also asked if when cooking on the stovetop or oven, which type of material they use for pots/pans: aluminum, copper, soapstone, clay, cast iron, enameled, non-stick (Teflon), stainless steel, glass, ceramic coating, stone coating. Also, what kind of containers do they use for storing food (raw or cooked): plastic that is reused (packaging: ice cream boxes, water bottles, etc), plastic boxes, glass containers, plastic boxes with BPA-free designation, metallic stainless-steel containers, aluminum containers, containers where they cooked with (pot/pan). People were asked if they did maintenance of their pots, pans, and food storage containers, replacing them if scratched. Additionally, were also asked if they knew how to wash and store utensils for cooking and storing food to keep them intact and not scratched. They were also asked if when washing cookware in the dishwasher, freezing, and cooking or heating food in containers they check the FCM symbols of the cookware. In some questions, an assessment on a Lickert scale was used, with the increasing importance of choice, while other questions required a direct answer, yes or no. In the third section, the perception of the safety of materials commonly used in cookware was evaluated through 8 questions, some using images for easier identification of the materials and symbols described. People were also asked if they knew the FCM symbols "for food contact" and "polyethylene terephthalate (PET)", and the meaning of BPA-free and DEHP-free, using multiple choice questions. The opinion regarding the safety of some materials for cooking and storing food (raw or cooked), was asked using a scale (unsafe, less safe, safe, don't know/don't answer). Furthermore, the consumer's perception regarding the risks associated with the use of cookware for cooking and storing food: contamination by pieces of material, migration of heavy metals, migration of carcinogenic elements/microplastics/substances that could interfere with hormones, was inquired. At the end of this section, 4 questions were also asked about the knowledge and interest in receiving more information about the FCM topic.

2.3. Statistical analysis

Descriptive analysis was carried out through absolute and relative frequencies given the qualitative typology of the variables. Inferential analysis was performed using non-parametric statistics. When the nature of the dependent variable was presented as nominal qualitative, the Chi-square test was used. For the comparison between two independent groups in the case of an ordinal qualitative dependent variable, the Mann-Whitney test was used, and when three or more independent groups, the Kruskal-Wallis test was used. In case significant differences were observed between the groups, the Dunn-Bonferroni multiple comparison tests were used. For this purpose, the conditions for applying this test were ensured, namely, the inexistence of >20% of expected frequencies below 5 and none below 1. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using IBM® SPSS software (Statistical Package for the Social Sciences, version 27).

3. Results

3.1. General characteristics of the study sample

The study sample was composed of 1179 adult participants, of which 1036 were female and 143 were male. Most of the participants belong to households with 3–4 people and had a higher educational level. Most of the respondents presented an average monthly income between 1000 and 3000 € and lived in the Lisbon Metropolitan Area. Data were analyzed according to the age group of the participants: ≤36 years (n = 366); between 37 and 44 years (n = 401) and aged ≥45 years (n = 412). As shown in Table 1, there were statistically relevant differences

Table 1
General characteristics of the study sample.

	Total Population (n = 1179)	≤36 years (n = 366)	37–44 years (n = 401)	≥45 years (n = 412)	P-value*
Gender, %					
Male	12.1	7.9	6.0	21.8	<0.001
Female	87.9	92.1	94.0	78.2	
Household, %					
≤ 2 people	31.4	40.4	19.5	35.0	<0.001
3–4 people	56.4	52.7	65.1	51.2	
≥5 people	12.2	15.6	15.5	13.8	
Education, %					
≤ High school	12.8	16.7	8.2	13.8	<0.001
Graduation	42.5	30.1	52.1	44.2	
≥ Graduation	44.7	53.3	39.7	42.0	
Family income net monthly average, %					
<1000€	8.7	13.1	6.7	6.8	<0.001
1000–3000€	57.7	63.1	57.9	52.7	
>3000€	28.1	17.2	31.2	34.7	
Doesn't know/ Doesn't answer	5.5	6.6	4.2	5.8	
Geographical area of residence, %					
Lisbon	67.0	57.1	67.1	75.7	<0.001
Center	16.6	21.6	15.0	13.8	
North	10.6	13.9	11.5	6.8	
Other	5.8	7.4	6.5	3.6	

concerning distributions by gender, number of people per household, level of education, average net monthly household income, and distribution by geographic area.

3.2. Safety, convenience, and durability were the most important characteristics in the choice of cookware for the whole sample of consumers analyzed

We aimed at investigating the importance that participants gave to different criteria when buying cookware. The results are shown in Table 2. Material safety was the most valued criterium by the inquired sample. The analyses by age group revealed that safety, convenience, and durability were considered the most important aspects when buying cookware to cook and store food by all age groups. For younger people, the price was also pointed out as a very important criterion for the choice of pots and pans. The valorization of the criteria when buying pots and pans varied significantly among the age groups for durability, price, design, safety, and sustainability. Regarding the choice of containers for food storage, differences among age groups were observed only for durability, price, and design.

3.3. Stainless steel, non-stick, and glass were the materials most used for cooking and storing food

Our second goal was to characterize the consumers' practices regarding the use of cookware. Table 3 shows the frequency of usage of different materials for cooking and storing food. Regarding materials for cooking, anti-adherent materials, stainless steel, and glass stand out for their greater use in all age groups. There were differences between groups in terms of the frequency of use of most materials.

Regarding food containers, glass stands out as the most used material in the whole samples and all age groups, followed by plastic boxes with or without BPA-free designation. The usage patterns of BPA-free plastic boxes, stainless steel containers, and pots and pans where food was cooked, were statistically different among groups.

3.4. The glass was the FCM considered safe by a higher percentage of consumers

In Table 4 the consumers' safety perception of different cooking and storage materials is shown. Regarding the safety of cooking materials, stainless steel and glass were the materials considered safe by a higher percentage of the study participants. On the other hand, aluminum was regarded by a higher percentage of individuals as an unsafe material.

Regarding the safety perception of materials for food storage, glass containers were, in general, associated with a greater perception of safety. More than 90% of the participants, in all age groups, classified this FCM as safe. Contrarily, the reuse of plastic containers (e.g., ice cream boxes, and water bottles), was classified as unsafe by the majority of individuals. These perceptions were noted across the three age groups, although some statistical differences were observed.

3.5. Younger consumers presented a less appropriate pattern of usage and maintenance practices of cookware

As the migration of potentially toxic substances, and consequently the safety of cookware, depends largely on the usage and maintenance practices, we characterized those aspects and these data are shown in Fig. 1.

While 62.3% of the analyzed sample reported knowing how to wash and store cookware and storing food utensils to keep them intact, just 48.9% of the participants declared to replace scratched items. A relevant percentage of the inquired individuals reported checking the FCM symbology when using cookware and food containers in the freezer and dishwasher, especially in the microwave. For all the practices analyzed, the younger group presented a statistically significant less adequate pattern.

3.6. A general lack of knowledge about FCM safety symbols and mentions was observed

Regarding FCM symbology, there seems to exist a general lack of knowledge in all age groups (Fig. 2). From the total sample analyzed, 52.3% of these individuals recognized the "for food contact" symbol, and only 21.9% identified the "PET" symbol. Among the study participants, 48.9% answered correctly to the meaning of the mention "BPA-free", with a higher percentage of correct answers obtained in the younger group ($p < 0.001$). Regarding the mention of "DEHP-free", only 15.5% of the individuals were able to correctly identify its meaning.

3.7. A high percentage of consumers perceived FCMs as a source of contamination

The consumers' perception of the risk of contamination by FCMs is shown in Fig. 3, Over 80% of the study participants considered that contamination by pieces of material, and migration of heavy metals and carcinogenic elements can be associated with cookware materials. As far as materials of food containers are concerned, between 80 and 90% of the sample recognized the risk of contamination by pieces of material, plastic components, microplastics, and carcinogenic elements. These risk perceptions were similar in all age groups, with no statistical differences.

Table 2
Consumers' rating of product characteristics when buying cookware.

	Total Population(n=1179)			≤36 years(n=366)			37–44 years(n=401)			≥45 years(n=412)			P-value*
	1	2	3	1	2	3	1	2	3	1	2	3	
When purchasing PANS/PANS/FRYING PANS, what importance do you give to the following aspects?, %													
Durability	4.1	11.3	84.7	1.9	11.5	86.6	3.5	9.5	87.0	6.6	12.9	80.6	0.012
Price	4.8	20.1	75.2	3.0	15.6	81.4	3.5	19.7	76.8	7.5	24.5	68.0	<0.001
Design/Aesthetics/Color	28.0	41.4	30.6	32.8	37.4	29.8	28.2	44.4	27.4	23.5	42.0	34.5	0.023
Convenience/material advantages	4.7	12.3	83.0	4.6	14.5	80.9	3.7	12.7	83.5	5.6	10.0	84.5	0.443
Material safety	3.1	8.2	88.7	3.0	12.0	85.0	2.2	8.7	89.0	3.9	4.4	91.8	0.017
Sustainability and environmental issues	11.8	26.6	61.6	14.5	30.9	54.6	10.2	29.4	60.4	10.9	20.2	68.9	<0.001
When purchasing CONTAINERS for food STORAGE, What importance do you give to the following aspects?, %													
Durability	3.9	13.6	82.5	2.2	12.0	85.8	3.0	12.0	85.0	6.3	16.5	77.2	0.001
Price	5.3	21.1	73.5	3.6	17.5	79.0	4.0	22.4	73.6	8.3	23.1	68.7	0.003
Design/Aesthetics/Color	24.3	38.5	37.2	28.1	39.1	32.8	23.2	40.7	36.2	22.1	35.9	42.0	0.021
Convenience/material advantages	3.7	10.9	85.3	3.6	11.2	85.3	2.2	14.5	83.3	5.3	7.3	87.4	0.376
Material safety	2.4	6.6	91.0	2.2	8.5	89.3	1.3	8.0	90.8	3.6	3.6	92.7	0.305
Sustainability and environmental issues	8.7	20.4	70.9	9.8	23.0	67.2	7.5	21.2	71.3	9.0	17.2	73.8	0.155

*p-value for comparisons between the groups tested using the Kruskal-Wallis test. Scale of importance: 1-Not important; 2-Moderately important; 3-Important or Very important.

Table 3
Frequency of usage of different FCMs to cook and store food.

	Total Population (n = 1179)				≤36 years (n = 366)				37–44 years (n = 401)				≥45 years (n = 412)				P-value*
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
When cooking on the stove or oven, you usually use POTS/PANS of which material?, %																	
Aluminum	50.0	22.1	13.2	14.6	46.2	20.8	14.8	18.3	52.1	19.2	12.7	16.0	51.5	26.2	12.4	10.0	0.003
Copper	84.9	10.9	3.0	1.3	88.3	8.5	2.2	1.1	88.3	8.2	1.7	1.8	78.6	15.5	4.9	1.0	<0.001
Soapstone	93.8	4.5	1.4	0.3	95.9	2.5	0.8	0.8	95.3	3.2	1.5	0.0	90.5	7.5	1.7	0.2	0.003
Clay	53.4	25.9	16.8	3.9	60.7	23.0	12.8	3.6	54.1	24.7	16.7	4.5	46.4	29.6	20.4	3.6	<0.001
Cast iron	56.3	14.1	17.3	12.3	58.2	13.7	14.8	13.4	60.9	11.0	15.2	13.0	50.2	17.5	21.6	10.7	0.070
Enameled	68.5	16.7	11.1	3.7	72.4	13.4	10.9	3.3	70.8	17.5	9.0	2.7	62.9	18.9	13.4	4.9	0.006
Non-stick (Teflon)	6.7	7.0	23.1	63.2	4.6	3.3	20.0	72.1	8.5	6.5	21.9	63.1	6.8	10.9	26.9	55.3	<0,001
Stainless steel	6.5	5.4	16.9	71.3	6.3	4.9	18.9	70.0	8.2	5.2	14.7	71.8	4.9	6.1	17.2	71.8	0.846
Glass	18.0	9.6	11.2	45.9	27.6	10.1	22.7	39.6	15.7	7.5	25.2	51.6	11.7	11.2	31.3	45.9	<0.001
Ceramic Coating	46.2	17.6	21.2	15.0	46.7	18.6	19.7	15.0	49.4	16.0	20.0	14.7	42.7	18.2	23.8	15.3	0.250
Stone coating	80.3	11.5	5.4	2.8	82.2	9.8	4.9	3.0	82.5	11.5	3.7	2.2	76.5	12.9	7.5	3.2	0.042
Usually, you store your food (raw or cooked), in what kind of containers?, %																	
Plastics that you reuse (packaging: ice cream boxes, water bottles, etc.)	47.2	26.7	15.2	10.9	43.7	28.1	17.5	10.4	48.6	28.7	15.0	7.7	48.8	23.5	13.1	14.6	0.234
Plastic boxes	13.3	16.9	28.2	40.0	15.0	19.1	27.3	38.5	11.2	21.2	30.7	36.9	13.8	15.5	26.5	44.2	0.199
Glass containers	2.0	2.5	16.7	77.1	1.9	3.3	17.2	77.6	1.8	3.5	14.5	80.3	2.2	5.8	18.5	73.5	0.061
Plastic boxes with BPA-free designation	25.3	22.1	27.1	25.5	25.1	21.6	26.8	26.5	20.5	22.2	26.4	30.9	30.1	22.6	28.2	19.2	<0.001
Metallic stainless steel containers	66.8	22.0	8.3	3.0	70.5	20.8	6.3	2.5	70.6	18.5	7.5	3.5	59.7	26.5	10.9	2.9	0.001
Metallic aluminum containers	83.4	13.4	2.6	0.6	83.6	12.3	3.3	0.8	83.8	14.0	2.0	0.3	82.8	13.8	2.7	0.7	0.901
In the container where you cooked it (pot/pan)	46.1	28.8	18.2	6.8	42.9	28.4	22.1	6.6	44.4	30.2	17.7	7.7	50.7	27.9	15.3	6.1	0.037

*p-value for comparisons between the groups tested using the Kruskal-Wallis test. Frequency of use: 1-Never; 2-Rarely; 3-Sometimes; 4-Often.

Table 4
Assessment of consumers' safety perception of food cooking and storage materials.

	Total Population (n = 1179)			≤36 years (n = 366)			37–44 years (n = 401)			≥45 years (n = 412)			P-value*
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	
What is your opinion regarding the safety of the following food COOKING materials?, %													
Aluminum	31.6	33.9	23.2	25.7	32.2	27.9	29.4	33.4	23.9	39.1	35.9	18.5	<0.001
Copper	15.9	29.1	31.7	12.8	27.9	32.0	14.7	27.9	30.2	19.7	31.3	33.0	0.269
Soapstone	8.1	12.6	16.6	6.0	12.6	18.6	8.7	11.7	14.5	9.5	13.6	17.0	0.146
Clay	4.7	23.3	57.5	1.6	18.9	62.8	4.5	19.5	58.4	7.5	31.1	51.9	<0.001
Cast iron	5.9	14.0	62.3	4.9	13.1	60.9	6.5	13.2	59.9	6.1	15.5	65.8	0.787
Enameled	15.2	30.0	26.0	15.3	26.0	22.4	16.2	30.7	22.7	14.1	33.0	32.5	0.047
Non-stick (Teflon)	10.2	25.1	55.6	9.3	26.2	54.1	12.2	22.4	55.6	9.0	26.7	56.8	0.925
Stainless steel	1.9	6.8	81.2	0.6	9.0	78.7	3.0	8.2	76.8	1.9	3.4	87.6	0.004
Glass	2.1	5.9	82.1	3.6	7.4	76.2	1.5	6.2	83.0	1.5	4.1	86.4	0.010
Ceramic Coating	3.4	14.9	55.7	2.7	15.9	53.0	4.0	15.2	53.9	3.4	13.8	60.0	0.472
Stone coating	4.8	13.7	32.4	3.6	16.1	29.2	5.2	13.0	30.2	5.3	12.1	37.4	0.325
What is your opinion regarding the safety of the following (raw or cooked) food STORING materials?, %													
Reused plastics (Ex: ice cream boxes, water bottles, etc.)	61.2	29.8	6.3	63.4	30.3	4.1	61.6	30.7	4.5	58.7	28.4	10.0	0.170
Plastic boxes	25.1	48.4	24.3	28.7	51.1	18.6	25.7	51.4	20.0	21.4	43.2	33.7	<0.001
Glass containers	0.3	2.0	94.6	0.0	0.8	95.6	0.3	0.5	96.5	0.5	4.4	91.8	<0.001
Plastic boxes with BPA-free designation	4.2	17.0	53.9	3.8	21.0	53.6	3.2	16.7	60.6	5.3	13.6	47.6	0.166
Metallic stainless steel containers	16.2	24.3	40.2	13.4	24.3	41.3	17.2	21.5	38.7	17.7	27.2	40.8	0.384
Metallic aluminum containers	44.4	30.8	8.8	40.4	31.2	12.0	40.4	31.4	8.2	51.9	29.9	6.6	0.005
Pot/pan used to cook	35.1	37.7	14.7	32.8	40.2	12.8	32.2	38.2	16.5	40.1	35.2	14.6	0.136

*p-value for comparisons between the groups tested using the Kruskal-Wallis test. Safety perception was rated on a 3-point scale, where 1 was considered as "Not safe" and 3 was considered as "Safe".

Regarding the migration of substances that may interfere with the hormonal system, 56.4% and 58.4% of consumers acknowledge this risk associated with cookware and food storage materials, respectively. While for other types of contaminants, the percentage of "don't know/no opinion" responses was low (8–14%), about 35% of the respondents answered this option for substances interfering with hormones (data not shown).

3.8. The majority of participants were interested in increasing their knowledge about materials for food cooking and storage

As shown in Fig. 4, 71.2% of the sample referred that they do not feel enough informed when choosing cooking and storage materials. Regarding the interest in obtaining more information about materials for food cooking and storage, the large majority of participants (96.9%) answered that they were interested in increasing their knowledge about this topic. In terms of preferred means to receive this type of information, participants stated that they would like to be informed through websites/blogs, leaflets, and information disseminated through social networks (data not shown).

4. Discussion

In recent years, FCMs have attracted attention due to the risk of

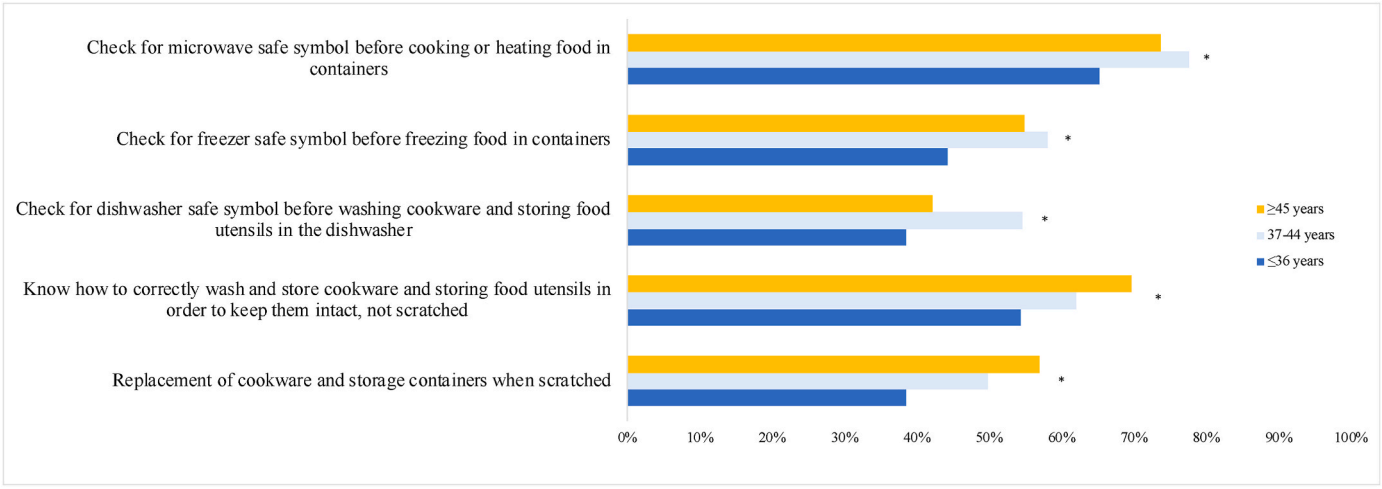


Fig. 1. Consumers' practices in the maintenance and use of cookware.
Shown results for the total population (n = 1179). *Statistical differences between analyzed age groups ($p < 0.05$).

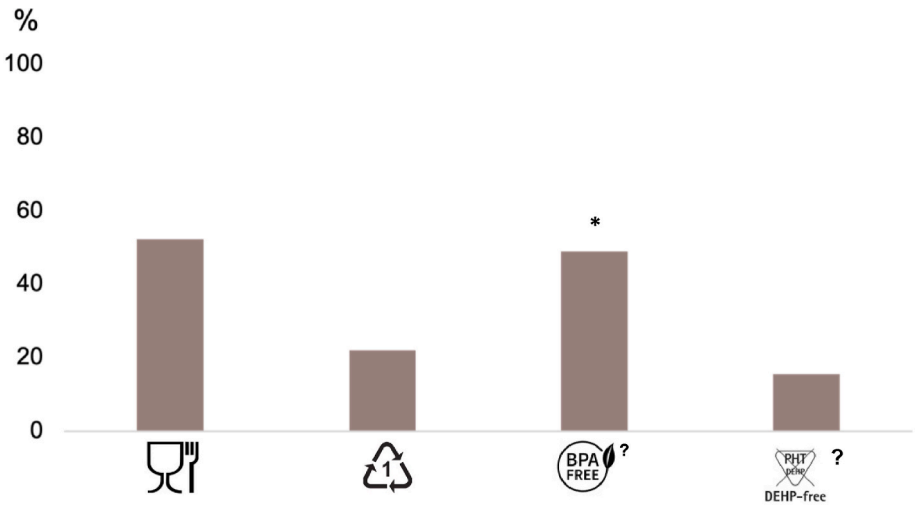


Fig. 2. Evaluation of the consumers' knowledge of FCM safety symbols and mentions.
Shown results for the total population (n = 1179). *Statistical differences between analyzed age groups ($p < 0.05$).

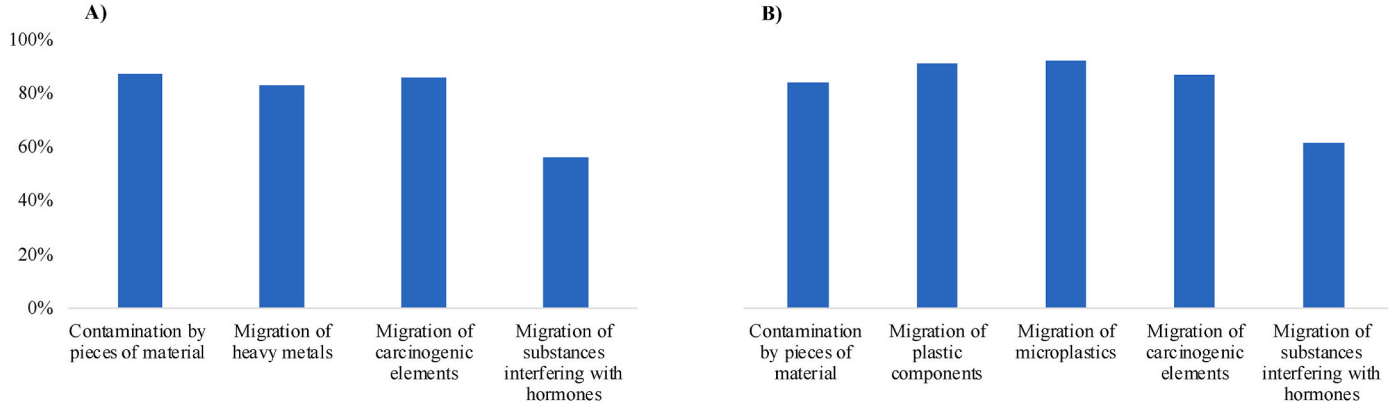


Fig. 3. Assessment of consumers' perception of the risk of contamination by A) cookware, and B) food storage materials.
Shown results for the total population (n = 1179).

migration of food contact chemicals (FCCs) suspected to be hazardous and to contribute to adverse health effects in humans or the environment (Groh et al., 2021). Despite the existent regulation, the current safety assessment of FCM is insufficient to ensure human health protection, as it does not cover all substances (Muncke et al., 2017) that can be present in FCM, and some FCCs are not sufficiently assessed for their impacts on

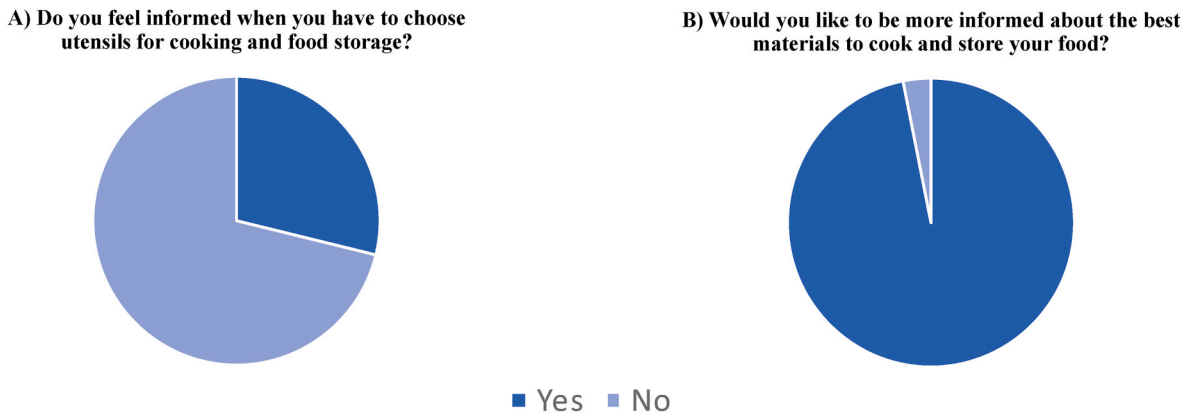


Fig. 4. Consumers' information regarding FCM for cooking and food storage.

human health (Muncke et al., 2020). Furthermore, the real usage conditions might be distinct from those used in the migration studies needed for the safety assessment. Therefore, it is important to characterize the preferences and usage practices of consumers. These aspects can differ due to sociodemographic aspects and particularity with age. Different studies have shown that food choices vary among age groups (Massaglia et al., 2019; Ogundijo et al., 2022; Zuo et al., 2022). As such, our starting hypothesis is that age could also influence consumers' behavior towards FCM used to cook and store food.

Our data demonstrate that age influences cookware purchasing decisions, although safety, convenience, and durability were valued by all age groups. Safety was considered the most relevant criterion for all ages, especially for older consumers. Price was more relevant for younger individuals. This is possibly related to the lower income of this group. A study by Massaglia et al. regarding purchasing choices of fruits and vegetables also found that price-sensitive consumers emerged among the youngest respondents, associated with the lowest average income (Massaglia et al., 2019). Younger individuals, particularly Generation Z, are considered more concerned about the environment and sustainability than previous generations when making food choices (Su et al., 2019). However, our results demonstrate that sustainability and environmental issues were more valued by older respondents. Interestingly, a multinational study that explored the use of sustainability labels on food products has shown that while respondents expressed concern with sustainability issues at the general level, lower levels of concern were found in the context of concrete food product choices. Following our data, this study also found that older respondents reported more use of a range of sustainability-related information available on food packages (Grunert et al., 2014).

In our sample, stainless steel, non-stick, and glass were the materials reported to be used more frequently. Glass and stainless steel were also the materials associated with a better perception of safety, which is under the valorization of safety by the analyzed sample. Glass is indeed considered a safe FCM as it presents low chemical complexity (Geueke et al., 2022) and originates low migration of chemicals to food (European Commission et al., 2017).

Stainless steel kitchenware is widely used and is generally considered not to be dangerous to human health. However, it has been described that nickel and chromium could be released from stainless steel cookware during food preparation (Guarneri et al., 2017; Kamerud et al., 2013). The oral ingestion of these metals can elicit or exacerbate allergic cutaneous reactions or systemic dermatitis in sensitive individuals. Studies that simulated the typical cooking process of acidic foods (e.g., tomato sauce) in stainless steel pots showed elevated Ni and Cr concentrations in food. The extent is dependent on stainless steel grade, cooking time, and cookware usage. It increased with cooking time, and was higher with unused pots, at lower pH, or in the presence of EDTA. The amounts released were generally below known allergy-triggering thresholds, making stainless steel kitchenware a safe option for the general population. However, it may be prudent for highly sensitive patients to avoid stainless steel, as the leached Ni may exceed the individual threshold for triggering allergy (Guarneri et al., 2017; Kamerud et al., 2013).

Non-stick pots and pans are also commonly used by all age groups, probably due to their convenience. However, only half of the respondents consider this FCM as "safe". Bradley et al. investigated the migration of coating materials from twenty-six non-stick-coated cookware samples, under conditions that simulate the actual use (Bradley et al., 2007). There was no detectable release of perfluorochemicals (PFCs) and none of the substances identified had the potential to exceed its tolerable daily intake (TDI) value. A similar conclusion was drawn by Choi et al. who evaluated the migration of PFCs from non-stick pans and pots from the Korean market (Choi et al., 2018). Usage conditions, namely temperature, may impact the safety of non-stick cookware. Perfluoroalkyl carboxylic acids (PFCA) may be emitted from heated polytetrafluoroethylene (PTFE) surfaces at high temperatures. However, even under overheating scenarios (>260 °C), the estimation of human exposure was revealed to be far below the TDI (Schlummer et al., 2015).

Aluminum is not perceived as safe by the majority of the survey participants, especially among the oldest ones. This age group also reported using aluminum cookware less frequently. Aluminum is associated with detrimental health effects on the hemopoietic system, the nervous system, and bones (Stahl et al., 2017). Transfer of aluminum from FCM to food can occur and is dependent on temperature, duration of cooking, the addition of sugar and salt, and pH (Stahl et al., 2017). The preparation of acidic products, like tomato sauce, in aluminum cookware, may result in the release of large amounts of aluminum (Stahl et al., 2018), that under certain circumstances can significantly exceed the Tolerable Week Intake (TWI) specified by the European Food Safety Agency (EFSA) of 1 mg/kg body weight (Stahl et al., 2017).

Regarding food storage, glass, and plastic boxes are the most used materials. Regular plastic boxes are used more often than BPA-free food containers, although they are regarded as less safe. Comparing age groups, a higher percentage of older participants classify plastic boxes as safe. This perception concurs with the usage practices, as this age group uses fewer BPA-free plastic boxes. Also, the correct identification of the mention "BPA-free" was higher in the youngest group. This result may be related to the stricter limits imposed in the EU for BPA in FCM, and especially to its prohibition in the manufacture of FCM intended to feed infants in 2011 (Commission Directive, 2011). Included sample under 45 years old is likely more aware of this issue.

Some reports have shown that both intentionally added substances (IAS), i.e. additives used in the production of plastics, and non-intentionally added substances (NIAS), i.e. derivatives and degradation/oxidation products, may migrate from plastic FCM to food (Díaz-Galiano et al., 2023). Among the FCCs are endocrine disruptors such as

BPA or phthalates. These compounds have been associated with health problems in animal models and humans, including infertility, testicular dysgenesis, premature breast development, and recurrent miscarriage. However, exposure levels from plastic food containers do not appear to constitute a threat, since migration levels are very low and generally fall within safe limits (Bang et al., 2012; Fang et al., 2017).

Although dietary exposure from migrated substances should not constitute a health risk (Shin et al., 2021), the transfer of migrants from FCMs to food under cooking conditions could be considerably higher (Díaz-Galiano et al., 2023). For example, during microwave cooking not only there is an increased transfer of FCCs, but also new potentially toxic substances are formed (Díaz-Galiano et al., 2023). These findings highlight the importance of using cookware according to FCM symbology. Although the analyzed sample value FCM safety, a high percentage of the participants does not check the symbology and/or have little knowledge about it. It is difficult to compare these findings with other populations due to the scarcity of similar studies. However, despite some lack of knowledge demonstrated herein, our results are markedly different from those obtained in a sample of Varanasi city, in India, in which only a very small percentage of the respondents understood the mention "BPA-free plastic", was aware of about leachable chemicals, and identified resin identification codes (Sharma et al., 2021). While both samples were highly-educated, socio-demographic and cultural differences may justify the observed discrepancies.

The analyzed sample values safety and recognizes the risk of migration of contaminants with potential health effects. Even so, many participants pay little attention to maintenance cookware or FCM symbology. Older individuals reported being more knowledgeable about the procedures to maintain cookware and keep it intact. In addition, a higher percentage of older respondents declared to replace scratched items, which can be related to a higher income. As a limitation, it should be assumed that the sample of this study was generally urban and highly educated. As the survey was disseminated through university and nutrition channels, our sample is likely to be more health-conscious than the global population. Also, the percentage of male participants in our sample is low. A large body of research demonstrates that women are more likely than men to be involved with cooking and all the foodwork (Mills et al., 2017). This is particularly true for the traditional Portuguese society, justifying the majority of female respondents. The cross-sectional design of the study is also a limitation of the present analysis since do not allow to establishment of a cause-effect relationship. Nevertheless, some strengths should be also recognized, mainly the large sample analyzed. Our data reveals the need to promote awareness regarding the health hazards of FCM and the best usage practices. Accordingly, the majority of the respondents reported the need to be more informed about cookware.

5. Conclusions

Safety was the factor considered most important when choosing cookware materials, and stainless steel and glass were considered the safest materials for cooking. Nevertheless glass and plastic were the materials most used to reserve food. It's important to note that the majority of the sample recognized the risk of food contamination through cookware. Additionally, our study demonstrates that there is a general lack of knowledge regarding the FCM symbology, and remarks on the need to disseminate reliable information to the general public about cookware, contributing to greater literacy in health and less exposure to food contact chemicals.

CRediT authorship contribution statement

Joana Moura: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Cíntia Ferreira-Pêgo:** Conceptualization, Methodology, Writing – review & editing. **Ana Sofia Fernandes:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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